Astrometry of WDS 21055+6210

Benjamin Mathis,[1] Erika Sjoblom,[2] Jackson Lewer,[1] and Paul J. McCudden [1]

[1]*Colorado Mountain College 1275 Crawford Ave Steamboat Springs, CO 80487, USA*
bdmathis@mail.coloradomtn.edu
[2]*Soroco High School, Oak Creek, CO 80467, USA*

Abstract

The triple star system WDS 21055+6210 was analyzed using the Las Cumbres Observatory Global Telescope Network (LCOGT) and the Ball Observatory in Steamboat Springs, CO, USA. The mean position angle of the A and B stars was found to be 297.98 degrees and the mean separation was 6.93 arc-seconds. These measurements are consistent with previous measurements of the A and B stars in the system. Further analysis of Gaia data indicates it is likely that the A and B star pair is optical, not physical. The B and C stars, however, are an excellent candidate for speckle interferometry and may be a physical pair.

1. Introduction

To choose a viable double star candidate for astrometric CCD observations, the following criteria were imposed:

1. The pair is in the Washington Double Star catalog (WDS)
2. The listed separation of the pair is between 4-8”
3. The magnitude of the A star is between 8 and 13
4. The magnitude difference of the pair is less than 2
5. The most recent observation of the pair is at least 5 years old
6. The total number of observations of the system is at least 10
7. The WDS lists the pair’s nature as a binary as undetermined

Using Dave Rowe’s Double Star Selection Tool (Rowe), the system WDS 21055+6210 in Cepheus, at RA 21h 5m 32.42s, Dec +62°9’ 21.9” was chosen in Stella Doppie (Sordiglioni, 2016). The A and B stars have a Δmag of 0.99, with the primary magnitude of 8.32. The pair were first observed in 1825 and were discovered to be a triplet in 1904 (Hussey, 1904). Representative historical data for the A, B system is shown in Table 1 below.

Table 1. Representative Historical Data for WDS 21055+6210 A, B

Date	Separation (arcsec)	Position Angle (°)
1825.01	6.83	302.5
1844.42	7.20	301.4
1901.71	7.33	283.4
1921.24	7.16	300.0
1956.71	6.95	303.8
1991.70	6.96	296.3
2005.72	6.95	298.8
2016.70	7.06	298.0

For this paper only the A, B system was analyzed, as the separation of the B and C stars is too small to detect without using advanced (e.g., Speckle) techniques.

2. Equipment and Methods

Las Cumbres Observatory (Brown, 2013) was used remotely to gather data on WDS 21055+6210, using a 0M4-SCICAM-SBIG camera with a Bessel-V clear filter. Forty 5-second exposures were taken on November 4 (JD 2459522.69744) and 8 (JD 2459527.35183), 2021 from Haleakala and on November 17 (JD 2459529.70179), 2021 from Tenerife, of which 27 were usable. Additional data was collected on December 15, 2021 (JD 2459563.52642) using the Ball Observatory on the campus of Colorado Mountain College in Steamboat Springs, CO using an 11" Celestron Edge SCT with an SBIG STF8300M camera and FW5-8300 filter wheel (although we used a clear filter), controlled by The Sky X Pro software. 43 images were taken at 4 second exposures, of which 11 were used and were plate solved using AstroImageJ (Collins, 2017).

Figure 1. Ball Observatory, Steamboat Springs, CO

Figure 2. Haleakala Observatory, HI

Position angles and separations were then measured for all images using AstroImageJ. Raw data can be found in the Appendix. Aladin (Bonnarel, 2000) was used to gather previously captured images of our system (Figures 3 and 4).

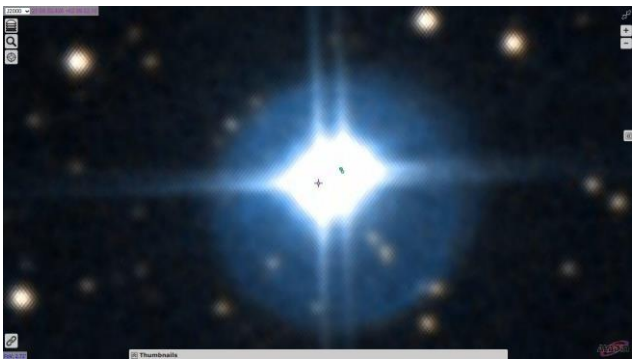

Figure 3. WDS 21055+6210, from Aladin

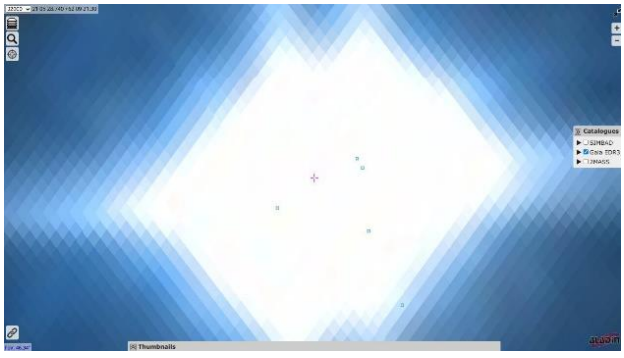

Figure 4. Primary, secondary and tertiary stars from Aladin

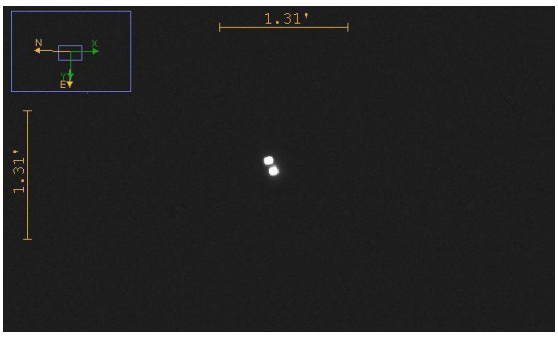

Figure 5. WDS 21055+6210, from AstroImageJ

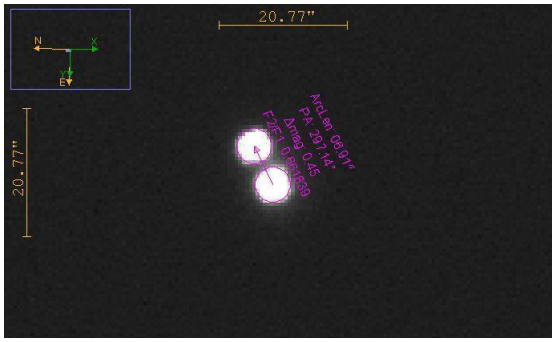

Figure 6. Sample measurements from AstroImageJ

Richard Harshaw's Plot Tool (Harshaw, 2020) provided data plotting and collation of the Gaia DR2 data collected via Vizier's (Gaia Collaboration, 2018) database, and Harshaw's Statistical Tool (Harshaw, 2014) was utilized to compare proper motions of the stars to determine the likelihood of them being a physical pair.

3. Data

A complete table of data is listed in the appendix. Our measurements show the A and B stars to have a mean angular separation of 6.93" and a mean position angle of 297.98°.

Table 2. Measured Data Results for WDS 21055+6210

	Mean	Standard Deviation
Position Angle (deg)	297.98	0.44
Separation (arcsec)	6.93''	0.09

Other parameters for the stars collected from Gaia DR2 data are shown in Table 3.

Table 3. Gaia Data for WDS 21055+6210

	A Star	B Star
Spectral Type	A	G
T-eff (K)	9,100	5,248
Mean Distance (pc)	276	535
Luminosity ($L_{\odot}$)	31.9	39.2
Absolute Magnitude	1.08	0.86
Parallax (arcsec)	3.62	1.87

4. Discussion

Our measurements closely fit with historical data but show no clear trend (see Figure 7). In addition, analysis of the proper motions of the A and B stars results in a Harshaw Statistical Tool (Harshaw, 2014) value

of 0.8, indicating a strong likelihood that the A and B stars are in fact an optical pair and not physical. The B and C stars may be physical, but unfortunately could not be resolved in our images.

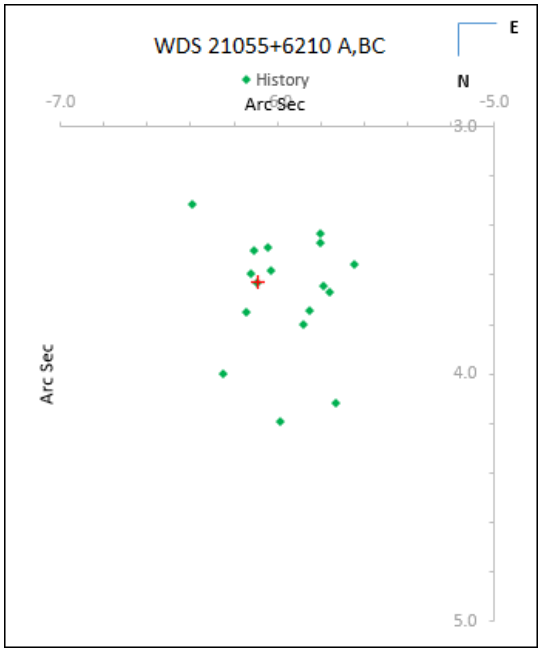

Figure 7. Historical (green) and new (red) data for WDS 21055+6210

5. Conclusion

We have mostly ruled out the possibility that stars A and B are a gravitationally bound pair. Our data was not able to resolve stars B or C. Stelle Doppie gives the B and C stars' separation as 0.8 arcsec, which might make them a good candidate for speckle techniques. A fourth companion star appeared in SIMBAD, but it is unknown whether this is incorrect data or if there is actually an additional companion star. More research is needed.

Acknowledgements

We would like to thank Sophia Risin and Rachel Freed for several productive conversations and advice, and Dr. Brian Mason at the USNO for providing historical data. This research has made use of the Washington Double Star Catalog maintained in the U.S. Naval Observatory. This work has made use of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.

References

Bonnarel, F., et al (Apr. 2000). "The ALADIN interactive sky atlas. A reference tool for identification of astronomical sources". In: *A&AS* 143, pp. 33–40. doi: 10.1051/aas:2000331.

Brown, T. M., et al (2013). "Las Cumbres Observatory global telescope network". In: *Publications of the Astro- nomical Society of the Pacific* 125.931, p. 1031.

Collins, K. A., et al (2017). "AstroImageJ: Image processing and photometric extraction for ultra-precise astronomical light curves". In: *The Astronomical Journal* 153.2, p. 77.

Gaia Collaboration, et al (2018). "VizieR Online Data Catalog: Gaia DR2 (Gaia Collaboration, 2018)". In: *VizieR Online Data Catalog*, pp. I–345.

Harshaw, R. (2014). "Another Statistical Tool for Evaluating Binary Stars". In: *Journal of Double Star Observations* 10.1, pp. 32–51.

Harshaw, R. (2020). “Using Plot Tool 3.19 to Generate Graphical Representations of the Historical Measurement Data” *Journal of Double Star Observations* 16.4, pp. 386–400.

Hussey, W. J. (Jan. 1904). “Observations of one hundred new double stars : eighth catalogue”. In: *Lick Observatory Bulletin* 65, pp. 53–60. doi: 10.5479/ADS/bib/1904LicOB.3.53H.

Rowe, D.. *Double Star Selection Tool*. url: https://www.dropbox.com/sh/eowlk0q4u39c7do/AACw3uZcogaxiud79Fj70tr6a?dl=0.

Sordiglioni, G. (2016). *Stella Doppie Double Star Catalog*.

Appendix

Table 4. Raw Data – WDS 21055+6210

Date	Julian Date	Position Angle (deg)	Separation (arcsec)
11/4	2021.8433	297.64	6.93
11/4	2021.8433	297.79	6.97
11/4	2021.8433	298.32	7.01
11/4	2021.8433	297.50	6.95
11/4	2021.8433	297.82	7.00
11/4	2021.8433	297.87	6.98
11/4	2021.8433	297.40	7.01
11/4	2021.8433	297.16	7.03
11/7	2021.8515	298.01	7.00
11/7	2021.8515	298.04	7.01
11/7	2021.8515	297.50	6.91
11/7	2021.8515	298.00	6.96
11/7	2021.8515	298.00	6.98
11/7	2021.8515	297.86	6.99
11/7	2021.8515	298.19	7.02
11/7	2021.8515	298.07	7.00
11/7	2021.8515	297.76	6.97
11/15	2021.8734	298.45	7.02
11/17	2021.8734	298.40	6.92
11/17	2021.8734	297.73	6.81
11/17	2021.8734	298.01	6.99
11/17	2021.8734	298.53	6.98
11/17	2021.8734	299.15	6.67
11/17	2021.8734	297.92	6.94
11/17	2021.8734	299.34	6.81
11/17	2021.8734	297.37	6.99
11/17	2021.8734	297.44	7.03
11/22	2021.8925	297.85	6.93
12/14	2021.9528	297.70	6.89
12/14	2021.9528	298.36	6.84
12/14	2021.9528	297.51	6.77
12/14	2021.9528	297.93	6.96
12/14	2021.9528	298.06	6.94
12/14	2021.9528	298.17	6.82
12/14	2021.9528	298.16	6.78
12/14	2021.9528	297.67	6.81
12/14	2021.9528	298.13	6.91
12/14	2021.9528	297.93	6.70
12/14	2021.9528	298.49	6.97